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CONSTRUCTED WETLANDS TO TREAT TEXTILE INDUSTRY WASTEWATER USING *PHRAGMITES KARKA*

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ABSTRACT

Textile factory wastewater belongs to one of the main contributor to the water pollution in Indonesia. The sources of wastewater in textile factory mostly coming from the dyeing process. Wastewater normally discharged directly into the surface water without treatment processes causing pollution and are harmful to the surface water. A constructed wetland to treat wastewater from textile factory has been built in textile factory in Sumedang Regency, Indonesia, in June 2018. Water samples from both influent and effluent were taken every 7 days and analysed for COD, DO, pH and colour. The objective of this study was to find out whether combination of pre-treatment and constructed wetland planted with *Phragmites karka* can meet the discharge requirements corresponding to 150 mg/L chemical oxygen demand (COD), pH 6-9 and colour 200 Pt-Co according to the Indonesian standard for textile industry. The results of this experiment showed that the average of treatment efficiencies during the period from December 2018 to March 2019 for COD and colour were 88.04% and 94.56% respectively, whereas the average concentration of COD in effluent of constructed wetland was 91.25 mg/L and colour was 200 Pt=Co. The overall results showed that COD concentration and colour in effluent were already lower than the Indonesian standard for textile factory wastewater, therefore it can be safely discharge into the public water.

KEY WORDS : Constructed wetland, *Phragmites karka*, Textile industry wastewater, Water pollution, Pre-treatment

INTRODUCTION

High population growth in Indonesia have increased the demand of textile materials and textile industries. The textile industries in Indonesia arebelongs to labour intensive industries that absorbed as many as 3.58 million people. According to Sachin *et al*. (2010) synthetic dyes are used quite intensive for adding colour to fibres such as cotton, silk, wool and also synthetic materials such as nylon, polyester and acrylic in textile industries. This process consume a large volume of water and chemicals (Sivakumar *et al*., 2013), which discharge a large volume of dyeing effluent as waste with or without treatments into public waters. The amount of dies used in the textile industry determine the volume of water required for production (Irina-Isabella Savin and Romen Butnaru, 2008). Azo dyes are synthetic dyes which mostly used in many textile industries (Yaseen and Scholz, 2016). The typical of dye wastewater effluents are high in colour, pH, suspended solids (SS), COD (Verma *et al*, 2012), BOD and metals (Sofia, 2000; Sekomo *et al*. 2012). High concentration of dyes in receiving public water will prevent light penetration and reducing respiration and aquatic organisms (Reema *et al*., 2011). Wastewater from textile industry contain many types of pollutant, such as tannins, alkalis, sulphides, COD, BOD, solids, colours, heavy metals, nutrients depending on different kinds of manufacturing process (Vymazal, 2014). Wastewater from textile industry has deleterious effect such as toxicity, carcigonic effect and mutagenicity to life (Khataee *et al*., 2012), and also other solution substances (Sofia *et al*., 2000), therefore wastewaters from textile industry should be treated before being discharged into the public water. Removals of such pollutant are usually achieved by using either conventional or natural treatment technologies.Various methods such as aerobic and anaerobic microbial degradation, coagulation (Vera *et al*., 2005) and biological system can be used to remove various pollutants for textile wastewater (Hoda, 2010). The biological treatment series including wetlands can help reduce the load pollution up to 90% so that waste water quality standards are expected to be fulfilled and the general public can accept the color of liquid waste discharged into the river body.

Constructed wetlands for wastewater treatment (CWs) are engineered ecosystems designed by humans to remove pollutants from wastewater. Constructed wetland systems imitate the treatment that occurs in natural wetlands by relying on heterotrophic microorganisms and aquatic plants and a combination of naturally occurring biological, chemical and physical processes (Vymazal, 2010). Constructed wetland for wastewater treatment is one of wastewater treatment alternative to conventional wastewater treatment system in Indonesia which is expensive and high-technology based (Kurniadie and Kunze, 2000; Kurniadie, 2011). Furthermore Kurniadie and Kunze, (2000) stated that due to expensive cost of building wastewater treatment facility, treatment of wastewater in Indonesia before entering the river or other public waters is still less done. The industrial wastewater including textile wastewater belong to the second biggest water pollution in Indonesia. According to Kurniadie (2011) the highest water pollution in Indonesia are domestic wastewater (40%), industrial wastewater (30%) and agricultural wastewater, animal husbandry wastewater and other kinds of wastewater. Right now in Indonesia around 50% of the wastewater from textile industries have been given treatment before discharge into public waters, while the rest is discharged directly into public water causing a lot of environmental pollution problem such as eutrophication. Textiles and dyeing wastewater causes significant environmental pollution, such as high concentrations of organic matter and colorants (dyes) (Olejnik and Wojciechowski, 2012). Conventional biological treatment, chemical and physical treatment processes are commonly used to remove the colorants from textile wastewater. However, physicochemical treatment processes can be unsuitable due to the high chemical and operating costs and byproducts formation often more dangerous than degraded substances. CWS have proven to be an effective alternatives for treating wastewater, due to low cost of construction and use of natural processes, in contrast to complex high-maintenance conventional wastewater treatment. CWs hopefully will lead to more ecologically-sustainable wastewater treatment in the future especially in developing country like Indonesia.

The objective of this study was to find out whether combination of chemical pre-treatment and constructed wetland planted with *Phragmites karka* can meet the discharge requirements corresponding to 150 mg/L chemical oxygen demand (COD), pH 6-9 and colour 200 Pt-Co according to the Indonesian standard for textile industry.

MATERIALS AND METHODS

The research was carried out in the Textile factory PT Kahatex Bandung Indonesia to treat wastewater from textile factory. Chemical polarization was used as a pre-treatment before treated in constructed wetland. The wastewater from equalization tank(COD value 900-1200 mg/L was taken as much as 1 m^3 per day (Figure 1) and then flowed into the polarization tank with a volume of 1 m^3. In the polarization tank there is a coagulation and flocculation process with the addition of chemical compounds. In the first rotation, wastewater was rotated for 20 – 25 minutes at 1000 – 1500 rpm of speed and NaOH compound was added as much as 5000-6000 ppm. The addition of Na OH is required to increase the pH value until pH value of 13. The second rotation, wastewater is rotated for 5 – 10 minutes by adding $FeCl_2$ as much as 5000-6000 ppm, so that bond particles are formed at pH 7 – 8. The treated wastewater enters the chemical sedimentation process for separate particles that have been bound with the treated wastewater. In the chemical sedimentation process, flocks have been formed from the process of flocculation and coagulation will settle at the base of Clarifier (Figure 1). The COD in sedimentation tank reduced to 400 mg/L.

The next process, wastewater is flowed into wetland basin with the volume 1 m^3/day of incoming wastewater. In the first 24 hours after the wastewater have a filtration process where the

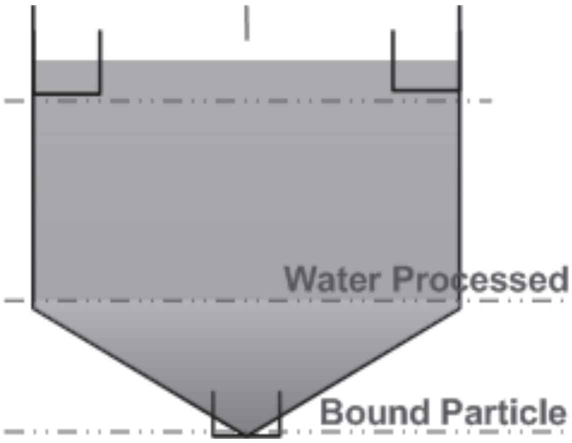


Fig. 1. Chemical Sedimentation Process

particles are still present in the wastewater will be filtered so that the outgoing wastewater of 4.6 L/ hour or 0.04 $m^{3/}$ hour. On the second day after 25 hours, the wastewater will come out with a volume 0.05 m^3/hour with a pollutant load reduction of COD = 40 – 60 ppm, pH = 7 and DO =6 at the wastewater outlet. In sedimentation tanks there will be separation of sludge and treated water. Sedimentation tank residence time is 30 minutes. The wastewater from sedimentation tank then flowed into the constructed wetland via polyethylene pipe (1 m long) by gravity (Figure 2).

A constructed wetland with the size of 5.0 m long, 3.0 m wide and 1 m deep to treat wastewater from sedimentary tank. The constructed wetland is a subsurface flow constructed wetland (15 m^3, vertical flow, continuous feeding and drainage system spread over the whole bed area), planted with *Phragmites karka* at a density 16 plants per m^2. The constructed wetland was sealed with clay soil and polyethylene membrane and it was built from multi layers with sand as the main media. Small size of gravel (8-16 mm) was used in the first top layer (10 cm), followed by 10 cm of bigger size of gravel (16-32 mm). River sand was used as the main layer (60 cm deep), followed by 10 cm of small size of gravel (8-16 mm) and finally, at the bottom, 10 cm larger size of gravel (16-32 mm). The wastewater was mechanically pre-treated in anequalization tank, polarization and sedimentation tanks (Figure 2).

The water samples from influent of equalization tank, effluent of polarization tank and effluent of wetland were taken every 7 days and analyzed for a period of 4 months (December 2018 until March 2019). All samples were analyzed in the wastewater Laboratory of PDAM Bandung, Indonesia, for COD, pH, colour and DO. The total detention time was 9 days. The residence time of wastewater in constructed wetland is 24 hours.

Pre-treatment

Pre-treatment are important to the constructed wetlands performance. High concentration of COD

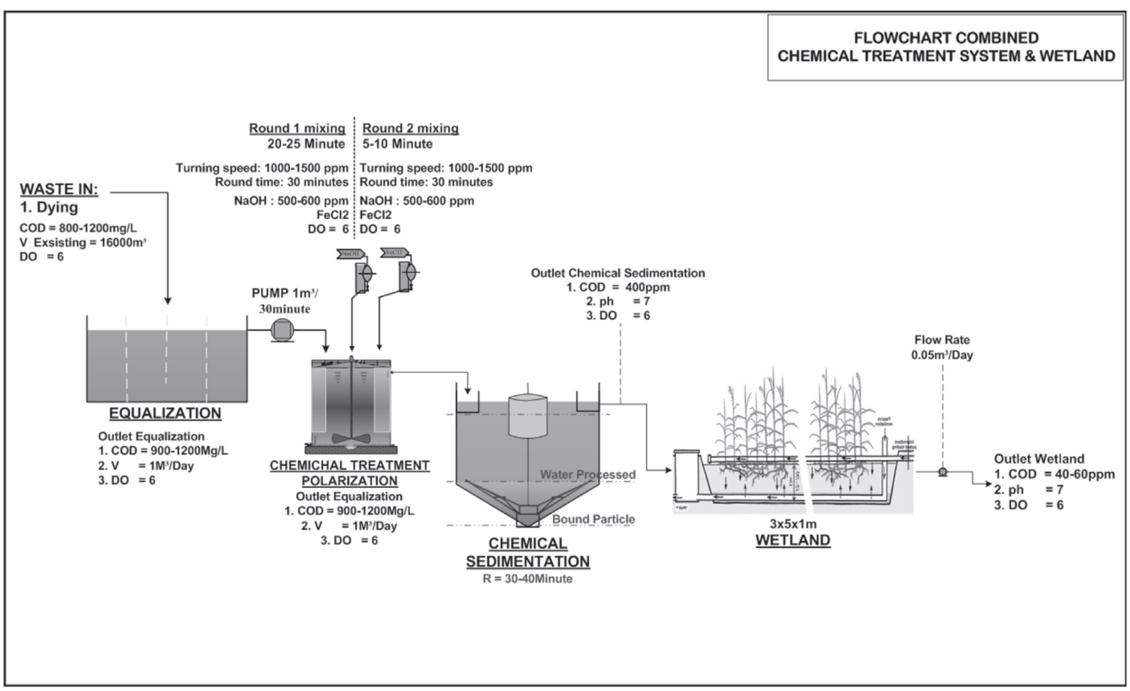
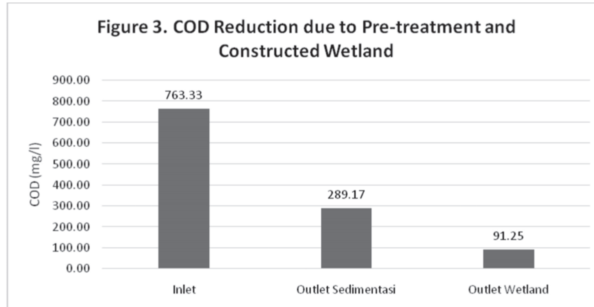


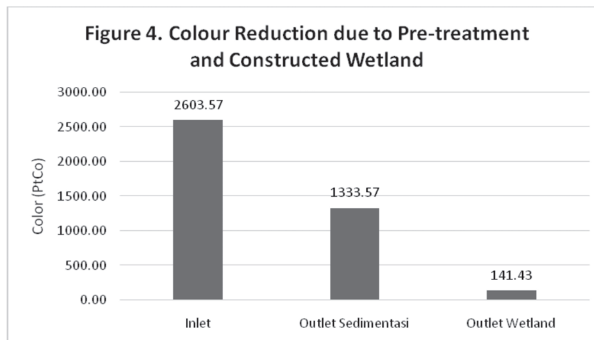
Fig. 2. Combined of pre-treatment and constructed wetland to treat wastewater from textile industry.

(800-1200 mg/L), colour of wastewater and accumulation of solids shortensthe effective life of a constructed wetland, so pretreatment strategy was required. Polarization through stirring and adding Na OH and Fe $Cl_2$and also sedimentation reduce the concentration of COD from 702-829 mg/L to 205-401 mg/L or the reduction percentage ranged from 51.62% to 70.79% (Figure 3). Sedimentation tanks can remove solids and ideally release only liquid effluent for treatment within the wetlands. According to Biddlestone *et al.* (1991) using mechanical aeration device and a sedimentation tank was recommended for pretreatment subsurface vertical flow wetlands. Sedimentation tank (volume 1 m^3) was designed to separate the solid and liquid materials from textile wastewater. The solid materials will be settled on the bottom of the sedimentation bed by gravity.

RESULTS AND DISCUSION

The treatment efficiency of constructed wetland to treat textile wastewater in PT Kahatex factory in Bandung Indonesia, has already high enough, although this constructed wetland was in operation for only four months. During the period of analysis from December 2018 until March 2019, the average concentration of COD in influent of equalization tank was 763.25 mg/L, pH 7.18 and colour was 2603.57 Pt-Co, whereas the average concentration of COD and colour in outlet of sedimentation tank or the inlet of constructed wetland was decreased to 289.16 mg/Land colour 1333.57 Pt-Co (Table 1, and Figure 3). The removal percentage from pre-treatment (polarization and sedimentation tanks) were 58.81% for COD and 48.78% for colour. The average concentrations of COD, pH and colour in outlet of constructed wetland were 91.25 mg/L for COD, pH 8.67 and colour 141.43 Pt-Co. These concentrations of COD, pH and colourin outlet of constructed wetland were already lower than the Indonesian standard for textile factory wastewater which is 150 mg/L for COD,6-9 for pHand 200 Pt-Co for colour (Ministry of environment Republic Indonesia, 2019). The whole removal efficiency of for COD and colour from constructed wetland were 88.04% and 94.56% respectively (Table 2).





The main pollutant in textile industry wastewater were pH, Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD_5), Total Dissolved Solid (TDS) and colour (Riyanto, 2013). The typical of dye wastewater effluents are mostly high in colour, pH, suspended solids (SS) and COD (Verma *et al*, 2012). According to Cooper and Green (1995) constructed wetland with vertical flow system can achieve full BOD_5 and COD removal because of high amount of oxygen transfer trough the reed bed. The average concentration of oxygen in this constructed wetland was raised from 2.93 mg/Ldissolved oxygen in inlet of equalization pond to5.27 mg/L in outlet of constructed wetland.

Table 2. Removal percentage from Polarization tank, sedimentation tank (pre-treatment) and constructed wetland (main treatment).

No	Parameter	Pre-treatment		Removal	C Wetland	Total	Indonesian
		Inlet	Ou4let	(%)	Outlet	Removal (%)	Standard
1	COD (mg/L	763.25	289.16	58.81	91.25	88.04	125
2	Colour (Pt-Co)	2603.57	1333.57	48.78	141.43	94.56	200
3	pH	7.18	7.35		7.01		6-9
4	DO	2.93	3.07		5.27		

Usually BOD_5 and COD removal in constructed wetland with vertical flow system was higher than constructed wetland with horizontal flow system, due to constructed wetland with vertical flow system has higher oxygen content (Platzer and Mauch, 1997) and better substrate aeration (Bahlo and Wach, 1992). The most important function of macrophytes plant roots and rhizomes in subsurface flow constructed wetlands in term of organic matter removal is supply of oxygen to aerobic bacteria (Brix and Schierup, 1989). The colloidal and soluble BOD_5 and COD remaining in solution are removed as a result of the metabolic activity and physics-chemical interaction within the root zone (Wood, 1990).

CONCLUSION

The contamination of many public water in Indonesia due to textile industry wastewater is a serious problem which threatens not only the aquatic ecosystems, but also human health. In this study showed that the pre-treatment facilities (equalization tank, chemical polarization tank and chemical sedimentation tank) has the average of removal percentage of 58.81% for COD and 48.78% for colour. Thė average of whole removal efficiency from this constructed wetland from pre-treatment and main treatment was 88.04% for COD and 94.50% for colour. The average concentrations of COD and colour in outlet of constructed wetlands were 88.04 mg/L for COD and 94.56 Pt-Co for colour.

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